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See image for Certificate of Correction

TITLE: Automatic cross color elimination

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Abstract Text - ABTX (1):

Color crosstalk is determined between layers of an image storage medium based on the cross correlations and autocorrelations of noise in the grain pattern in each layer of the image storage medium. Rather than relying on prior measurement under laboratory conditions, the invention scans the storage medium in a plurality of spectral bands to derive the record stored in each of the dye layers. A computer derives the autocorrelations and the crosscorrelations of a group of pixels between the plurality of color records of the scanned images each of which corresponds to

one of the spectral bands.
The invention is based on the observation that as each dye layer is deposited separately in the film, one would expect that the "noise" from the grain boundaries in one layer to be independent from the "noise" due to the grain boundaries in other layers. If there is correlation in noise between separate color scans, it is because the scanner is measuring the grain boundaries in more than one layer in the color scans.

Brief Summary Text - BSTX (6):
A scanner is used to measure the optical modulation of each dye in the film to estimate the red, green and blue content of the original scene. A scanner designed to pick up frequencies in a reasonably wide range of frequencies within the red, green or blue bands will also pick up some **color crosstalk** from other dye layers. While the scanner can be designed to have a monochromatic sensitivity at the peak absorptions of the three dyes, e.g., a laser scanner, the narrower the spectral response of each color channel, the less the system efficiency or sensitivity. Most scanners use a band of frequencies for each color to improve their sensitivity, however, these wider spectral responses result in **color crosstalk**. If uncompensated, the "green" in the scanned image will be the result of some blue or red frequencies in the original image. Each combination of film and scanner will give different results. This problem is exacerbated, as mentioned above, by the fact that

each dye layer absorbs light
outside the desired band. Not only do each
combination of film and scanner
give a unique effect, but also the effect will also
change as the film ages.
Typically, the prior art compensated for **color**
crosstalk by tables of
laboratory measurements of different film and
scanner combinations. A
technician will enter in the appropriate data based
on the film being scanned
and the scanner being used. In addition to the
requirement for highly skilled
technician with knowledge of both film and scanner
characteristics, the prior
art does not compensate for the effects of age.

Brief Summary Text - BSTX (13):
These and other objects, features and advantages
are accomplished by
determining **color crosstalk** between layers of an
image storage medium based on
the cross correlations and autocorrelations of
noise in the grain pattern in
each layer of the image storage medium. Rather
than relying on prior
measurement under laboratory conditions, the
invention scans the storage medium
in a plurality of spectral bands to derive the
record stored in each of the dye
layers. A computer derives the autocorrelations
and the crosscorrelations of a
group of pixels between the plurality of color
records of the scanned images
each of which corresponds to one of the spectral
bands. The invention is based
on the observation that as each dye layer is
deposited separately in the film,
one would expect that the "noise" from the grain

boundaries in one layer to be independent from the "noise" due to the grain boundaries in other layers. If there is correlation in noise between separate color scans, it is because the scanner is measuring the grain boundaries in more than one layer in the color scans.

Brief Summary Text - BSTX (15):

After the correlations for the color records of scanned images are determined, correction values which compensate for the interaction of the dyes in the film and the scanner spectral sensitivity are calculated. These correction factors are used to mathematically process the scans of the film image to produce a scanned image free of **color crosstalk**. Once the image has been corrected for **color crosstalk**, aging effects in the film can be quantified. Age related changes in color density can be compensated.

Detailed Description Text - DETX (3):

Each of the red 22, green 24 and blue 26 images, will largely include portions of the image associated with their respective visible spectra. For example, in the green record 24, the leaves are shown as this record has those components of the image with generally green hues. Also, the non-green portions of the image 14 are substantially absent in the green image 24. However, as described above, some of the information in the green record may be

the result of **color crosstalk** between the yellow and cyan layers in the films and the spectral sensitivity of the scanner in the green scan.

Detailed Description Text - DETX (10):

In FIG. 3, a representative system for image capture and measurement and correction of **color crosstalk** is shown. A color wheel 38 having a plurality of optical filters 40, specifically, red, green, blue and infrared filters, is used to separate the images in the various dye layers from the film 12. A light source such as a lamp 42 provides light in the red, green, blue and infrared spectra. As each of the appropriate color filters 40 are interposed between the film and the lamp, light in the red, green, blue and infrared wavelengths will be transmitted through the frame of the film and captured by a camera 42. Whereupon the video signal 46 generated may be delivered to suitable computer 48. Generating sequential color images may be automated as shown generally by control line 44 from the computer 48. The control line 44 would carry control signals to peripheral devices to advance the color filters 40 on the color wheel 38, advance the film 12 to the desired image 10 and control the intensity of the lamp 42 for the desired spectral response. The color monitor 50 is used to view the images as desired. A keyboard 52 provides user input to the computer 48.

Detailed Description Text - DETX (16):
FIG. 5 shows the process by which the correlated noise is separated from the scanned image. Once the red, green, blue and infrared images have been digitized and appropriately stored for retrieval, the image processing will commence by retrieving pixel data. Each pixel digitized and captured from the film image 10 will correspond to a red, green, blue and infrared pixel associated with the respective red, green, blue and infrared images 20-26 of FIG. 1. As each set of red, green, blue and infrared pixels correspond to the same location, their intensity values are associated and stored in and retrieved from the computer memory. For each group of pixels, the crosscorrelation of the noise between **colors, due to crosstalk** between the dye layers and the layers in the scanner, is determined.

Detailed Description Text - DETX (17):
Referring to FIG. 5, the scanned image data represented by arrow 100 are received. A raw blue pixel value is received in step 102; a raw green pixel is received in step 104. A raw red pixel is received in step 106 and an infrared pixel is received in step 108. These raw pixel values are the values seen by the scanner directly. They will contain some **crosstalk between the color** records, which the processing now described will remove. As will be discussed below with reference to FIG. 10, these pixels are first filtered by a high-pass

spatial filter to remove image detail from the grain, because the image detail would yield a false measure of correlations. Also, the filtering process will remove the DC frequency bias. This high pass filtering is applied respectively in steps 103, 105, and 107 of FIG. 5. The intensity values of the respective blue, green, red and infrared pixels are used to determine the autocorrelations and crosscorrelations at this pixel. In step 110, the autocorrelation for a particular pixel at location X,Y are determined by the equations,

Detailed Description Text - DETX (54):
The matrix of correction coefficients can now be applied to the raw **color scans to separate the color crosstalk** from the various records. FIG. 7 depicts one process in which the matrix calculated in FIG. 6 is used. The raw scan image values 200 are retrieved pixel by pixel in red 202, green 204, blue 206 and infrared 208 image intensity data streams. As an approximation to the real world and for reasons which are described below, the cubic root of the image intensities are calculated in step 210. In the linear transform step 212, the cubic root values are multiplied by the correction coefficients in matrix 213. The resultant values are cubed in step 214 to bring them up to the linear values, and stored as corrected red, green, blue and infrared data streams 216, 218, 220 and 222 to be assembled into the corrected scanned image values 230.

Detailed Description Text - DETX (64):
As mentioned above, the world is not linear, the method as described thus far could provide exact results if the scanner spectral responses were delta functions, like laser scanners. The entry into the cubic root domain provides a useful, yet approximate, method of solving the **color crosstalk** problem for scanners with broad spectral responses. However, a second embodiment of the invention described below, although much more computationally intensive, can provide more exact results.

Claims Text - CLTX (1):
1. A method for correcting for the effects of crosscolor **crosstalk between colors** of a color image stored in an image storage medium and an imaging device used to scan the color image into a plurality of scanned images each corresponding to a color of the color image, comprising the steps of:

Claims Text - CLTX (4):
correcting for **color crosstalk** in each of the scanned images according to the crosscolor correlations.

Claims Text - CLTX (11):
6. A method for reducing the effects of **color crosstalk between a color** image and a scanner used to scan the color image, comprising the steps of:

Claims Text - CLTX (16):
using the set of correction coefficients to produce a set of adjusted images corrected for **color crosstalk** from the set of scanned images.

Claims Text - CLTX (57):
26. A system for correcting for the effects of crosscolor **crosstalk between colors** of a color image stored in an image storage medium and an imaging device used to scan the color image into a plurality of scanned images each corresponding to a color of the color image, comprising

Claims Text - CLTX (60):
means for correcting for **color crosstalk** in each of the scanned images according to the crosscolor correlations between noise patterns.

Current US Original Classification - CCOR (1):
382/167